Momentum corrections for the data and the Monte Carlo

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For the MIPP Collaboration

July 20, 2011

Abstract

Corrections to total momentum of the data and the MC tracks and the methods used for these corrections are described. For the data, corrections are shown for LH_2 and Empty-Cryogenic target and all thin targets i.e. Beryllium, Bismuth, Carbon 2% interaction length and Uranium including Empty target at all the energies. For the MC, corrections are shown for thin targets at 120 GeV/c and Beryllium target at +58 GeV/c.

1 Corrections for the data

1.1 Overview of the problem

The total momentum distribution of straight-through tracks for the data was drawn for different targets and a Guassian function was fitted. It was observed that the average momentum of tracks is quite low and needs to be corrected. For example, for LH_2 target at +58 GeV/c, this value is 56.35 GeV/c. So momentum corrections are required.

1.2 Correction function

To correct for total momentum of the data tracks, a function has been written. This function is there in 'DSTUtil.cxx' with the name 'CorrMomData'. The function uses the scale factor from 120 GeV data which is the ratio of corrected and uncorrected momentum. The uncorrected momentum for 120 GeV data is 118.8 GeV/c and corrected momentum is 119.7 GeV/c (known for 120 GeV beam). The correction function takes the total momentum as the input and returns the corrected momentum after scaling it up. For the momentum corrections, we have divided all the data on the basis of run time-period and momentum. For thin targets including Beryllium, Bismuth, Carbon 2 % interaction length, Uranium and Empty target, we have 7 sets of data taken at different momenta and in different time-periods. For 59 GeV, we have two sets of data for thin targets. The run ranges for the two sets are 16098-16108 and 17087-17278 respectively. The corrections for thin target data sets at +58 and +59 GeV/c were shown [1]. For LH_2 and Empty-Cryogenic target, we have 16 sets of data at different momenta. The uncorrected and corrected momenta for straight-through tracks for different data sets are shown in table 1.

Data set	Mean momentum (GeV/c)	Corrected momentum (GeV/c)
Thin target +19.8	19.76	19.91
Thin target +58	56.44	56.89
Thin target +59	56.88	57.38
Thin target +59	57.82	58.26
Thin target -58	57.44	57.72
Thin target -60	57.61	58.03
LH_2 +19	18.44	18.61
LH_2 +19.8	19.51	19.67
LH_2 +20	18.59	18.72
LH_2 +58	56.35	56.78
LH_2 +59	56.85	57.27
LH_2 +84	81.96	82.56
LH_2 +85	81.87	82.49
LH_2 +86	82.12	82.74
LH_2 -19	18.56	18.74
LH_2 -19.8	19.78	19.92
LH_2 -20	18.77	18.91
LH_2 -58	56.6	56.92
LH_2 -59	56.58	56.93
LH_2 -84	82.66	83.2
LH_2 -85	82.86	83.4
LH_2 -86	82.66	83.17

Table 1: Table of values of uncorrected and corrected momentum for thin target (including Empty target) and LH_2 target (including Empty-Cryogenic target) data sets at different momenta.

2 Corrections for the MC

- Correction function

For the Monte Carlo, a profile of reconstructed vs true momentum is made and a polynomial is fitted [2]. For making the profile, the matched true and reconstructed tracks are selected along with a constraint that the absolute value of the difference of reconstructed and true momenta should be less than or equal to 3 times the momentum resolution for true momenta. The reconstructed momentum becomes a function of true momentum and can be written as f(T) = R where R is the reconstructed momentum and f(T) is the fitted polynomial. To get the true momentum for a particular reconstructed momentum, the zeroes of the function g(T) = f(T) - R have to be found. For that, we use the Newton-Raphson method. The formula used by this method is as follows:

$$T(n+1) = T(n) - (g(T)/g'(T))$$

$$T(n+1) = T(n) - ((f(T) - R)/f'(T))$$

T(n+1) and T(n) are $(n+1)^{th}$ and n^{th} roots of the function g(T) and $f'(T)$ is the derivative of the fitted polynomial. The method makes use of iterations. An initial value has to be given as the guess at the very 1st iteration. The root calculated at the 1st iteration becomes the initial guess for the 2nd iteration and so on. The correction function has been added to routine

‘DSTUtil.cxx’ with name ‘MCPtotCorr’. To use this function, the user has to give the fitted function, reconstructed momentum for which the correction is needed and an initial guess to the Newton-Raphson method.

The profile of reconstructed vs true momentum was made for C 2 %, Be and Bi targets at 120 GeV/c separately. All of them were more or less the same. So, the 3 targets were combined and the profile for reconstructed vs true momentum was made. It is shown in Figure 1. A polynomial containing 6 parameters $a+bx+cx^2+dx^3+ex^4+fx^5+gx^6$ is fitted to the profile in the range 0 to 120 GeV/c. 6 parameters were used since parameters less than 6 were not sufficient to fit the whole momentum range i.e. 0 to 120 GeV/c. The last point in the profile is not fitted as it results from the resolution effect. The resolution effect arises from the error in measurement of momentum due to which we have momentum values greater than 120 GeV/c in MCRECO. This is called momentum resolution. In MCTRUTH, we don’t have momentum resolution.

An initial guess of 120 GeV/c (true momentum) is used as input to the correction function. If the 6-parameter polynomial is used, the correction function returns a true momentum of $\sim$ 124.6 GeV/c for a reconstructed momentum of 118.5 GeV/c which is not reasonable. To figure out this problem, the fitted polynomial was extrapolated upto 130 GeV/c and superimposed on the profile of reconstructed vs true momentum. It is shown in Figure 2. It is observed that the function bends at the higher end of the momentum. So it gives non-reasonable values of the corrected momentum. To solve this problem, it has been decided not to fit the higher momentum region say after 110 GeV/c. A 3-parameter polynomial $a+bx+cx^2$ is now fitted to the profile of reconstructed vs true momentum in the range 0 to 110 GeV/c. It is shown in Figure 3. This polynomial was also extrapolated upto 130 GeV/c and was superimposed on the profile of reconstructed vs true momentum. It is shown in Figure 3. The function remains a straight line on the higher momentum end and returns reasonable values of corrected momentum. The values of uncorrected and corrected momenta for Be, Bi and C 2% targets at 120 GeV/c using the 3-parameter polynomial for the corrections are shown in table 1.

The profile of reconstructed vs true momentum for Be target at +58 GeV/c and a 3-parameter fit to the profile are shown in Figure 4. The function is fitted in the range 0 to 59 GeV/c. The last point in the profile is again not fitted. The function is extrapolated upto 65 GeV/c and superimposed on the profile of reconstructed vs true momentum. It is shown in Figure 5. An initial guess of 58 GeV/c (true momentum) is used as input to the correction function. The uncorrected momentum for Be +58 GeV/c is 57.64 GeV/c and the corrected momentum returned by the correction function is 58.08 GeV/c.

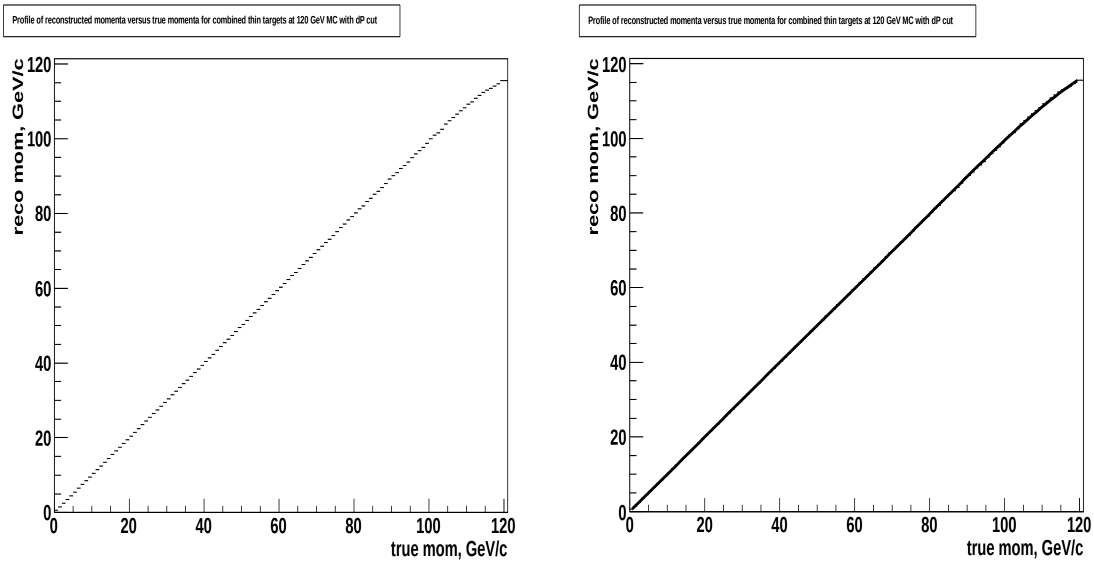

Figure 1: Left- Profile of reconstructed vs true momentum for combined thin targets at 120 GeV/c. Right- A 6-parameter polynomial was fitted to the profile of reconstructed vs true momentum for combined thin targets at 120 GeV/c in the range 0 to 120 GeV/c.

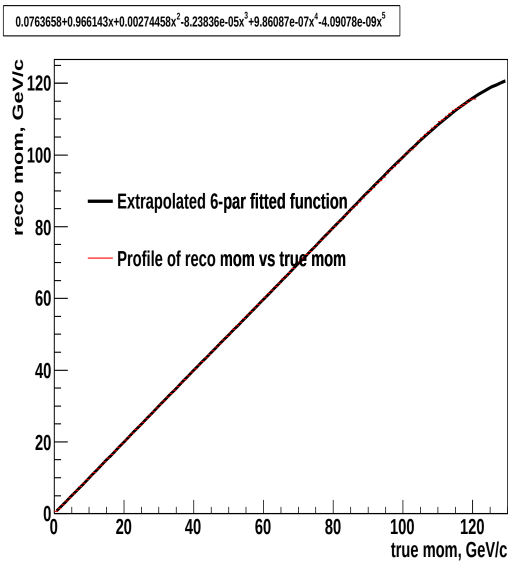

Figure 2: Extrapolated 6-parameter polynomial was superimposed on the profile of reconstructed vs true momentum for combined thin targets at 120 GeV/c.

Target	Uncorrected momentum(GeV/c)	Corrected momentum(GeV/c)
Be 120	118.7	119.51
Bi 120	118.6	119.41
C 2% 120	118.5	119.31

Table 2: Table of uncorrected and corrected momenta for thin targets at 120 GeV/c.

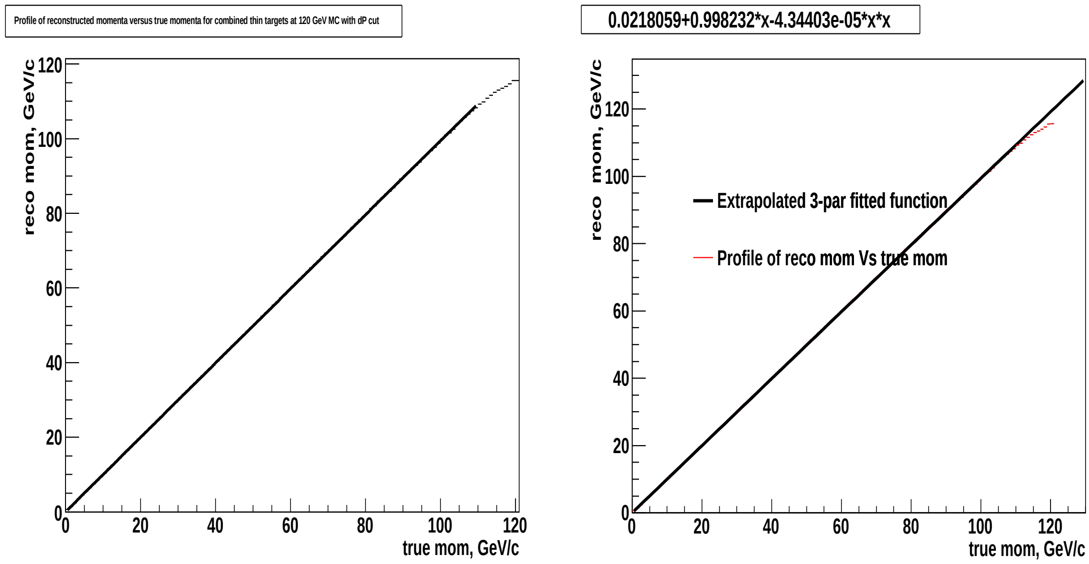

Figure 3: Left- A 3-parameter polynomial was fitted to the profile of reconstructed vs true momentum for combined thin targets at 120 GeV/c in the range 0 to 110 GeV/c. Right- Extrapolated 3-parameter polynomial was superimposed on the profile of reconstructed vs true momentum for combined thin targets at 120 GeV/c.

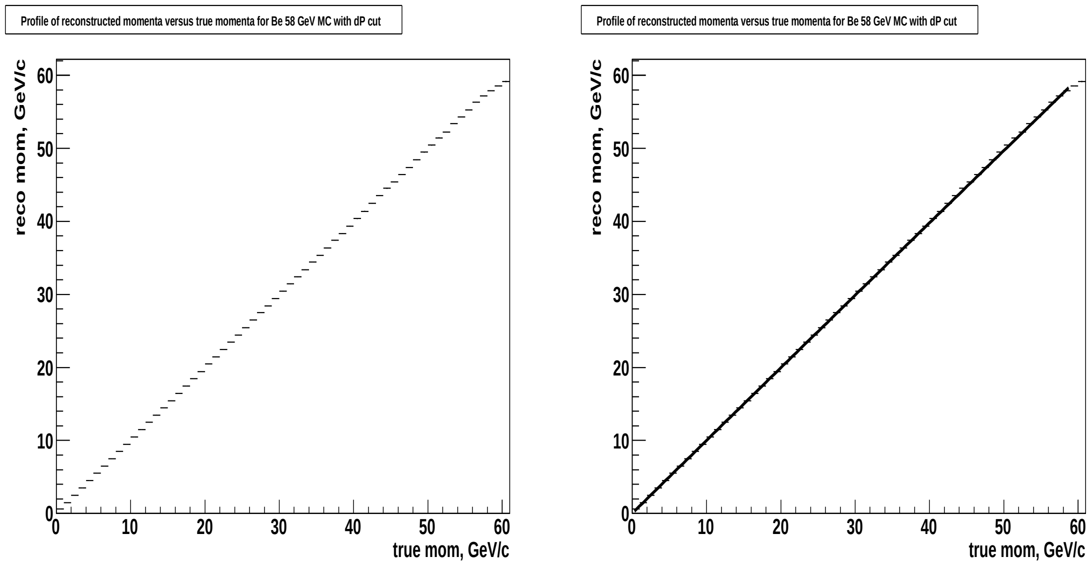

Figure 4: Left- Profile of reconstructed vs true momentum for Be target at +58 GeV/c. Right- A 3-parameter polynomial was fitted to the profile of reconstructed vs true momentum for Be target at +58 GeV/c in the range 0 to 59 GeV/c.

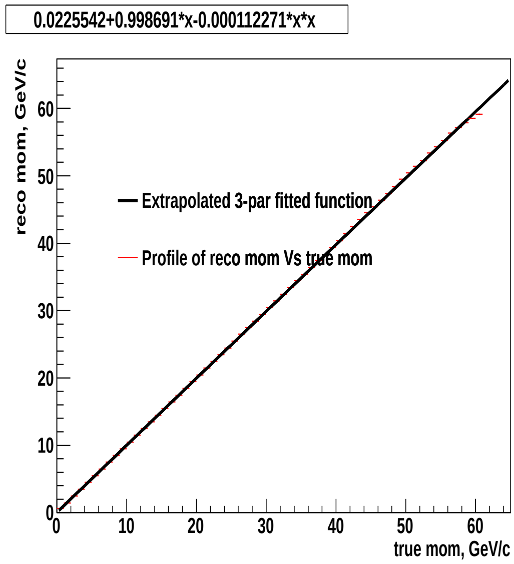

Figure 5: Extrapolated 3-parameter polynomial was superimposed on the profile of reconstructed vs true momentum for Be target at +58 GeV/c.

3 Conclusion

We have shown the momentum corrections for all the data sets including thin target and LH_2 target data at different momenta. For the MC, corrections have only been shown for thin targets at 120 GeV/c and Be target at 58 GeV/c. Similarly for the other targets i.e. LH_2 and thin targets at the other momenta, corrections can be made.

References

[1] The uncorrected and corrected momentum distributions for thin target data sets at +58 and +59 GeV/c were shown in weekly MIPP meeting. See MIPP-doc-1117-v1.

[2] The MC corrections were shown in weekly MIPP meeting. See MIPP-doc-1102-v1 and MIPP-doc-1105-v1.